

The Relationship Between Farm Size and Efficiency in South African Agriculture

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Commercial farms in South Africa could become significantly more efficient if they became smaller. The government could encourage that trend by removing policies and distortions that favor large over small farms.



Summary findings

Drawing on international evidence, van Zyl, Binswanger, and Thirtle discuss the sources of economies of scale. Using representative farm-level survey data for South Africa's six major grain-producing areas and one irrigation area for the period 1975–90, they:

- Describe the structure of South African agriculture, detailing the distribution of farm sizes and results from previous studies of farm-size efficiency.
- Analyze the evidence on scale efficiency in the former homelands.
- Analyze the relationship between farm size and efficiency in commercial farming and discuss how policy affects that relationship.

Clearly policy has a crucial impact on the relationship between farm size and efficiency. They find that:

- Farms in the former homelands seem to be scale-inefficient, which is unsurprising, given the historical lack of access to support services and infrastructure, policies that discriminate against farmers in the homelands, and the extremely fragmented and limited land-use rights of farmers there.

- There is an inverse relationship between farm size and efficiency in the commercial farming areas for the range of farms analyzed, regardless what method is used. This inverse relationship seems to become stronger and more accentuated as policy distortions — which tend to favor large farms over small ones — are removed.

- Large farms tend to use more capital-intensive methods of production, while smaller farms are more labor-intensive. And managerial ability seems to be better on larger farms.

There is an inverse relationship between farm size and efficiency in South African agriculture despite South Africa's history of policies favoring relatively large mechanized farms. Clearly, efficiency gains could be significant if commercial farms became smaller. To encourage that trend, policies and distortions that favor large farms over small should be removed.

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South African agriculture has the appearance of being sophisticated and highly successful. A closer look at the present structure and performance of South Africa's agricultural sector, however, reveals that despite the appearance of efficiency, the sector has followed a pattern of growth that is far from normal.² Although agriculture is generally characterized by constant returns to scale and an inverse relation between farm size and productivity (Binswanger, Deininger and Feder, 1993), the sector is dominated by relatively large farms that are owned and operated by a comparatively small number of individuals. International evidence indicates that a large-scale mechanized farm sector generally is inefficient, especially when compared to small-scale family type farm models. Although there may exist very real economies of scale, they are mostly 'false' because they are usually the result of policies which favor larger farms over small farms.

At least two questions related to the productivity relations in South African agriculture –both commercial and subsistence-- and the effects of size on these relations, which have not been adequately addressed, are important when considering land reform along the lines proposed for South Africa:

- Are large mechanized farms and the present commercial white farms economically efficient relative to smaller holdings?
- What is the role of past policies in determining these observed productivity relations?

If larger farms are not efficient relative to smaller farms, then smaller farms and equalizing the ownership distribution would enhance both efficiency and equity, and if policy created artificial economies of scale, they should be adjusted.

This paper has as objective to explore these issues by briefly reviewing the sources of economies of scale and international evidence on these issues, as well as analyzing representative farm-level data in both the commercial and former homeland sectors. These analyses are conducted against the policy environment and changes therein, as well as other factors which influence farm production.

² In its recent study, the World Bank (1994), supported by several other studies (see, for example, Van Zyl and Groenewald, 1988; Thirtle, et al, 1993 and Van Zyl, 1994), concluded that agriculture in South Africa appears to be a highly sophisticated and successful sector, but this appearance hides severe distortions and inefficiencies. Evidence that is often cited in support of the former view is the fact that South Africa is self-sufficient with respect to most of its major agricultural commodity requirements. At the same time, the sector's relatively small and declining share of GDP is seen as indicating a pattern of secular decline of agricultural production that is consistent with a normal pattern of economic growth and development (Van Zyl, Nel and Groenewald, 1988). A closer look at the present structure and performance of South Africa's agricultural sector, however, reveals that despite the appearance of efficiency, the sector has followed a pattern of growth that is far from normal (Van Zyl and Groenewald, 1988).

Values

"Efficiency for whom?" should be a central question in the determination of efficiency (Schmid, 1994). The issue can be conceptualized by the portrayal of two persons' indifference maps for two goods in a conventional Edgeworth box diagram. Any combination of goods held by the parties not on the contract curve is Pareto-inefficient, and any barrier to reaching the contract curve is inefficient. From any given starting place, the parties have a mutual interest in reaching the contract curve. But the portion of the contract curve that they can reach by mutually advantageous exchange is different for each starting place. Efficiency says nothing about the power question involved in choice of starting place and resulting equilibrium on the curve (Schmid, 1987; Bromley, 1989). Furthermore, any voluntary agreement to trade says nothing about any agreement as to the legitimacy of the starting place. If the original distribution of rights was illegitimate, any Pareto-improvement from it has no legitimacy either (Calabresi, 1991).

Since efficiency is always rooted in some distribution of rights, it can never be a basis for judging that distribution (Schmid, 1992). Rights are antecedent to efficiency calculations. In this context it is neither useful nor meaningful to conceptualize policy issues as efficiency versus distribution. The issue is efficiency 1 versus efficiency 2, each with a different starting place that resolves the questions of power and rights.

Given the skewed land ownership in South Africa and the way in which these land rights was derived, the question, "Efficiency for whom?", is extremely relevant for South Africa when comparing efficiency of different farm sizes and land distributions. Because the validity of the efficiency argument depends on the legitimacy of the rights prior to the calculation, the efficiency calculations cannot be the only criteria when deciding on land reform when the very basis of these rights is in question. With this perspective, this paper uses the existing distribution of rights to determine efficiency issues. It should, however, be acknowledged from the outset that this is not an attempt to justify this original distribution, but rather to show what the efficiency impacts and issues are given the existing distribution of power, wealth and rights.

International Experience On Economies Of Scale, Farm Size And Productivity

In examining the relationship between farm size and productivity, it is necessary to look first at the sources of economies of scale, which underpin the justification for the move towards large-scale production. In general these are: (i) lumpy inputs that cannot be used below a certain minimum level such as farm machinery and management skills; (ii) advantages in the credit market and in risk diffusion

arising from ownership of large holdings; and (iii) processing plants that transmit their economies of scale to farms, usually giving rise to wage plantations. A summary of the basic theoretical context is followed by a brief summary of these sources of economies of scale are followed by a brief description of international empirical findings and related issues. For a more detailed discussion on these, see Binswanger, Deininger and Feder (1993) and Johnson and Ruttan (1994).³

In theory, economies of scale are defined by a production function which exhibits a more than proportional increase in output for a given increase in magnitude of all inputs. In practice, the concept provides problems as there rarely is a situation when an increase in magnitude of some inputs does not imply a change in the factors of production (Peterson and Kislev, 1991). The general consensus of researchers on economies of scale is that they do not exist, except under very special circumstances. Empirical studies typically find constant returns to scale (see, amongst others, Johnson and Ruttan, 1994; Peterson and Kislev, 1991), although lumpy inputs, credit and risk diffusion, and processing plants can be important sources of economies of scale.

Sources of Economies of Scale

Lumpy inputs: Farm machinery -threshers, tractors and combine harvesters- are lumpy inputs, and reach their lowest cost of operation per unit at relatively large areas. With the advent of agricultural mechanization many people believed that the economies of scale associated with it are so large that it makes the family farm obsolete. Small owners would sell or lease their land to larger operators. However, it became quickly apparent that machine rental can permit small farmers to circumvent the economies of scale advantage associated with machines in all but the most time-bound of operations, such as ploughing and planting (seeding) in dry climates or harvesting where climatic risks are high. In those situations farmers compete for early service and therefore prefer to own their own machines. Thus, economies of scale associated with machines do increase the minimum efficient farm size, but by less than expected because of rental markets. The use of lumpy inputs leads to an initial segment of the production function that exhibits increasing returns with operational scale, but these technical economies vanish when farm size is increased beyond the optimal scale of lumpy inputs or when rental markets make the lumpiness of machines irrelevant.

Management skills, like machines, are an indivisible and lumpy inputs, so the better the manager, the larger the optimal farm size. Technical change strengthens this tendency. The use of fertilizers and pesticides, and arranging the finance to pay for them, require modern management skills. So does the marketing of high-quality produce. In an environment of rapid technical change, acquiring and processing information becomes

³ These issues are also addressed in World Bank (1995)

more and more important, giving better managers a competitive edge in capturing the innovator's rents. Therefore, optimal farm sizes tend to increase with more rapid technical change. However, some management and technical skills, like machinery, can be contracted from specialized consultants and advisory services or can be provided by publicly financed extension services. Contract farming for processing industries or bulk marketing companies often involves the provision of technical advice.

Access to credit and risk diffusion: Land, because of its immobility and robustness, has excellent potential as collateral, making access to credit easier for the owner of unencumbered land. On the other hand, rural credit markets are difficult to develop and sustain. There is therefore often severe rationing of credit, which can be partly relieved by the ability to provide land as collateral. The high transaction costs of providing formal credit in rural markets implies that the unit costs of borrowing decline with loan size. Many commercial banks do not lend to small farmers because they cannot make a profit. Raising interest rates on small loans does not overcome this problem, since it eventually leads to adverse selection. For a given credit value, therefore, the cost of borrowing in the formal credit market is a declining function of the amount of owned land. Providing funds to overcome emergencies is a common function of informal rural credit markets. However, the amounts small farmers can borrow for consumption are usually tiny, and often only at high interest rates. Investigations into how farmers and workers cope with disaster show that credit finances only a small fraction of their consumption in disaster years. Access to formal commercial bank credit therefore gives large modern commercial farmers a considerable advantage in risk diffusion over small farmers without access. Establishment of a viable credit function for the family farm is a *conditio sine qua non* of modern commercial farming. Hence emphasis is needed for all efforts to develop rural credit, including co-operative banking and other savings-mobilization mechanisms.

Economies of scale in processing: Wage-based plantations continue to exist for typical plantation crops, for example sugarcane, bananas and tea. This is not because of inherent economies of scale in producing these crops, rather economies of scale arise from the processing or marketing stage rather than from the farming operation and are transmitted to the farm. However, economies of scale in processing alone are not a sufficient condition for the explanation of the existence of plantations. The sensitivity of the timing between harvesting and processing is crucial as well, sugarcane, tea or the fruits of the oil palm have to be processed within hours of harvesting. Plantation style production has never been established for easily stored products such as wheat or rice which can be bought at harvest time in the open market and stored for milling throughout the year. Even sugarcane can be contracted for by millers with small farmers (e.g. in South Africa) as long as the logistics of harvesting and transportation can be solved. Thus, the superiority of the plantation depends on a combination of economies of scale in processing with a co-ordination problem. Plantations do not arise, or do not survive once labor coercion is abolished, unless both these conditions exist. In many cases, even where there is an even labor demand over the year, the

plantation mode of production has therefore declined sharply at the expense of smallholder production. This applies to commodities as diverse as sugarcane, tea, coffee, bananas, rubber and oil palm, as well as tobacco and cotton.

Wage plantations survive in areas where they were first established under conditions of low population density and with a large land grant. Where the same crops were introduced into existing smallholder systems, contract farming prevails. Processors seem not to have found it profitable to form plantations by buying out smallholders and offering them wage contracts. This suggests either that the co-ordination problem associated with plantation crops can be solved at a relatively low cost by contract farming, or that imperfections in the land sales markets are so severe that it is prohibitively expensive to create large ownership holdings by consolidating small farmers.

Evidence on the farm size - productivity relationship

The literature clearly demonstrates that a systematic relationship between farm size and productivity is the result of market imperfections, and then only when more than a single market is imperfect. For example, if credit is rationed according to farm size, but all other markets are perfect, land and labor market transactions will produce a farm structure that equalizes yields across farms of different operational size. But if there are imperfections in two markets, land rental and insurance, or credit and labor, a systematic relationship can arise between farm size and productivity.

In countries, like South Africa, where markets facing small farmers for any combination of labor, land, credit, land rental, insurance, etc., are often imperfect or missing (at least for some farmers, in general those who are small), this may give rise to real economies of scale over the short-term. However, these economies of scale are 'false' in the sense that they are only temporary, and the result of deliberate elimination of, or restrictions on, these markets.⁴ With development of these markets economies of scale diminish and eventually disappear. The issue thus is *not to pursue* a farm structure that over the short-term captures these benefits, but over the longer-term gets a country locked into an inefficient and inequitable structure centering on large-scale mechanized farms.

⁴ Under certain circumstances, such as those in South Africa, there are external economies of scale (Johnson and Ruttan, 1994). It occurs when, as firms or farms increase in size, they experience advantages in terms of access to inputs, credit, services, storage facilities, or marketing and distribution opportunities relative to smaller farms. This gives large farms real advantages relative to small farms due to pecuniary economies or policy distortions rather than to greater efficiency. On the other hand, diseconomies of scale may also occur, for example when the labour market fails or do not exist, when transaction costs in the labour market are high, or when the effort of hired labour is significantly affected by supervision (De Janvry, 1987).

Even without economies of scale, the question remains: Does size matter? Are larger farms more productive and/or profitable than smaller ones even if an argument cannot be made for superior technical efficiency? The answer clearly is yes. Policies are rarely scale neutral and external economies of scale is a reality. While these tend to favor larger farms, there are considerable transaction costs in the labor market, as well as supervision costs, which favor smaller farms. The issue is: What is the net effect of these factors?

Many studies on the farm size-productivity relationship reported on in the literature suffer from severe shortcomings such as not accounting for differences in land quality or labor productivity, using physical yields, and not accounting for differences in operational holding size and ownership holding size. Proper measures of efficiency are the difference in total factor productivity between small and large farms, and the difference in profits, net of the cost of family labor, per unit of capital invested. Studies which apply these measures typically support the following generalizations (Binswanger, *et. al*, 1993):

- *the productivity differential favoring small farms over large farms increases with the differences in size, implying that it is largest where inequalities in landholdings are the greatest, in the relatively land-abundant countries of Latin America and Africa, and smallest in land-scarce Asian countries where farm size distributions are less equal;*
- the highest output per unit area is often achieved not by the smallest farm size category but by the second smallest farm size class, suggesting that the smallest farms may be the most severely credit constrained.

However, most of the empirical work on the farm size-productivity relationship has been flawed by methodological shortcomings, and has failed to adequately deal with the complexity of the issues involved. In general, studies which come to grips with some of the problems consistently show the superiority of smaller farms over large farms.

Numerous studies provide empirical evidence at the micro-level of the existence of an inverse relationship between farm size and the efficiency of resource use - as farm size increases, efficiency declines. This relationship is basically due to higher efficiency of family labor as compared to hired labor, in combination with commonly observed imperfections in credit and land rental markets (Binswanger *et al*, 1993). Berry and Cline (1979) found that the value added per unit of invested capital for the second smallest farm size group (10 to 50 ha) exceeded that of the largest farm size groups (200 to 500 ha) in a majority of zones that did not specialize in plantation groups.

A World Bank study (World Bank, 1983) on the higher efficiency of small versus large farms in Kenya, found that output per hectare was 19 times higher and employment per hectare was 30 times higher on holdings under 0.5 hectare than on holdings over 8 hectares. At the national level, this meant that a 10% reduction in average farm size would increase output by 7% and employment by over 8%. Binswanger *et al* (1993) report similar results for many other countries. Chavas and Aliber (1992) found virtually no scale economies in dairy production, and the very limited initial scale economies they observed were attributable to lumpiness of certain inputs.

Evidence is also available at the macro-level, but only in terms of physical yields - an imperfect indicator of efficiency. Prosterman and Riedinger (1987) using data from 117 countries, show that 11 of the top 14 countries in terms of grain yields per hectare are countries in which small-scale, family farming is the dominant mode of production.

However, studies by Feder (1985) and Carter and Kalfayan (1989) demonstrate that the existence of market imperfections which tend to favor large farms (e.g. capital and insurance markets) may negate the inverse relationship between farm size and productivity. Carter (1994) finds that certain financial market disadvantages may render small farms non-competitive. Hence, whereas the small-scale farming strategy holds considerable promise from an efficiency perspective, this does not mean that its implementation is easy or can afford to ignore critical policy issues, such as resolving the usually constrained access of small farmers to credit markets.

Related Issues: Mechanization, Labor Organization and Farm Size

Also underlying the establishment and maintenance of large-scale farms is the misguided perception that there is a relationship between mechanization and large farms. This has been clarified in the literature (see Johnson and Ruttan, 1994). Capital intensity is explained by the substitution of capital for labor because of high wages. This substitution process, brought about by changes in relative factor prices (Peterson and Kislev, 1991), indirectly caused larger farms. Machinery allows farmers to work progressively larger units of land (Hayami and Ruttan, 1985).

In this respect, the work of Brewster (1950) on the influence of machinery on farm size is enlightening: Mechanization in industry involves stationary machinery, which implies that the number of workers can be increased substantially without increasing labor supervision costs. In agriculture, labor and machines are both mobile, making supervision expensive and increasing management costs. In addition, agricultural tasks are sequential in nature due to the annual cycle of production. This limits the opportunities for specialization and division of labor, which creates few advantages to expansion beyond the size of owner-operator.

The literature clearly demonstrate (*cf.* Berry and Cline, 1979; Binswanger and Rosenzweig, 1986; Binswanger and Kinsey, 1993; Binswanger and Elgin, 1992; Binswanger *et al*, 1993) that family farms are generally more efficient and superior to other types of farming because of the way in which labor relations are organized. Family farms are by definition farms where the owner is the operator and where his/her family provides the large bulk of the regular labor requirements throughout the year. While the definition of family farms does not exclude the hiring of other people, especially in a part-time capacity when related to seasonal labor, it tends not to rely too much on such behavior. In addition, in countries where capital is relatively scarce and expensive, the relationship between labor and capital should reflect this. Over-emphasizing modernization, restructuring, mechanization and other similar concepts implying the use of more capital to labor than that dictated by economic realities should be discouraged. This all implies farm sizes on the smaller side of the spectrum rather than larger sizes for family farms.

Structure Of South African Agriculture: Issues Related To Size

Farm Sizes in South Africa

Farm sizes in South Africa began to increase in the 1950s and continued to increase until the 1980s. After steadily increasing until 1971, black farm employment began to decline. Consequently, it can be argued that scale efficiencies appeared after 1950, and in particular after 1970, and were a main factor behind the steady decline of employment in agriculture (Van Zyl *et al*, 1987). Agriculture was the only major economic sector that experienced an absolute decline in employment between 1951 and 1985 -- despite the fact that wages were rising at a slower rate in agriculture than in other sectors. This history suggests that in South Africa, a number of interventions in the markets for land, labor and capital produced a structure of incentives which induced scale efficiencies, in particular since the 1970s.

From the beginning of the century until the 1950s, the number of farms and the total area cultivated increased, but the average farm size declined. After 1950 this trend is reversed; and farm size grew consistently, accelerating in the 1970s before leveling off in the late 1980s. Because the cultivated area remained the same, the number of farms declined -- from 116 848 units in 1950 to 62 084 units in 1990 (RSA, 1994). The pattern seems to continue until the late 1980s, although there is some evidence of an increasing differentiation in farm sizes below the 100-hectare minimum which (in some areas) defines a farm in official statistics (World Bank, 1994).

Average farm size increased from 738 hectares per farm in 1953, to 867 hectares in 1960, to 988 hectares in 1971, and to 1 339 hectares in 1981, but declined to 1 280 hectares per farm in 1988. From 1955 to 1988, average farm size by province increased from 1 284 to 2 663 hectares per farm in the Cape Province; 471 to 998 hectare per farm in the Orange Free State; 403 to 629 hectare per farm in the Transvaal, and 390 to 609 hectare per farm in Natal. These data show that the national average hides significant regional variations. In 1988, the median farm size was about 500 hectares, with farms in the high-potential areas significantly smaller. Such qualifications should not distract, however, from the fact that large-scale farms dominate South African agriculture, and that the average size of these farms is extraordinary by international standards.

Evidence of Economies of Scale

At present, there is mixed evidence for the existence of scale efficiencies in South Africa's commercial farm sector:

- The distribution of gross farm income in commercial agriculture is highly unequal: In 1988, 3% of the farmers earned 41% of the total gross farm income; 26% earned 81%, while the remaining 74% of farmers earned a mere 19% of total gross farm income (calculated from the 1988 agricultural census, CSS, 1993).
- Hattingh (1986) reports evidence of a direct relationship between farm size and efficiency in sheep farming in the Karoo and in cattle ranching in north-western Transvaal. Hattingh also reports that efficiency increased between small and medium-sized irrigated farms at Vaalharts and dryland grain farms in the Orange free State, before decreasing again on the larger farms (size ranges are not specific);
- Analyzing the Department of Agriculture's Production Cost Surveys, Moll (1988) finds no significant economies of size⁵ both in maize-cattle regions (Western Transvaal, North-West Orange Free State and the Transvaal Highveld) and in wheat-sheep regions (Swartland). Using re-tabulated 1983 census data, however, Moll (1988) finds economies of size, but only in the maize areas and for 50-300 hectare range.

Conversely, there exists empirical evidence from South Africa to suggest an inverse relation between farm size and efficiency. Statistics from the 1988 census of agriculture (CSS, 1993) show that

⁵ Moll (1988) measures economies of size (all factors but operator labour changing) as opposed to economies of scale (all factors changing).

50% of farming units owning only 6% of the farmland, with farm sizes of less than 500 hectares, were responsible for 30% of gross farm income, 23% of net farm income, 32% of capital investment, and 29% of farm debt. The larger farms (1000 ha +) comprising a third (33%) of all farming units, collectively owed more than 50% of the total farm debt. However, these farms were responsible for 53% of total gross farm income. Table 1 provides evidence on this skew distribution.

Table 1: Factor Intensities in Agriculture, 1988

Farming Unit Size Groups (ha)	Number of Farms	Gross Margin (R/ha)	Employees (No./1000ha)	Cash wage per worker (R/1000 ha)	Wages as % of gross income (%)	Current Expenditures (R/ha)
< 2	142	5 096.77	2 779.6	10 534.31	16.4	28 210
4	1058	3 421.24	1 082.6	469.13	17.1	8 160
9	1525	2 517.84	673.5	84.56	15.3	3 133
19	1815	614.38	379.7	25.78	21.4	1 283
49	4837	986.41	335.3	6.49	14.0	1 942
99	4404	384.23	172.9	2.94	16.8	840
199	5690	344.41	133.6	1.35	17.3	680
299	4502	170.83	84.0	0.99	16.4	424
499	7044	91.45	45.8	0.35	12.5	277
999	10926	87.55	27.1	0.13	10.2	177
1,999	9230	74.55	17.7	0.08	10.1	117
4,999	7588	38.46	7.8	0.05	9.6	56
9,999	2573	18.06	3.0	0.07	8.6	25
10,000+	1067	11.71	1.4	0.11	8.6	21
Total	62428	50.11	14.3	0.01	11.6	91

Source: 1988 Census of Agriculture data (CSS, 1993)

Christodoulou and Vink (1990), based on data obtained from the Central Statistical Service, which also covered the existing smallholdings in municipal areas, come to the following conclusions (Table 1):

- the gross margin per hectare was R1514 for small farms (below 500 ha), R87 for middle farms (500-1000 hectares), and R36 for farms above 1000 hectares. Moreover, small farms employed 632 workers per 1 000 hectares, compared to 27 and 29 workers per 1 000 hectares for middle and large farms, respectively;
- the cash wage per 1 000 hectares paid by small farms was on average R1 189, compared to 13 cents and 7 cents paid by middle and large farms, respectively;
- farm workers earned 16% of the gross income of small farms, but only 10 and 9% of the gross income of middle and larger farms;

- smaller farms' total farm expenditures were nearly R5 000 per hectare, whereas middle and larger farms spent only R177 and R55 per hectare, respectively.

The comparative efficiency of black, small-scale farming versus white, large-scale farming is very difficult to assess. More than a century of policy interventions has suppressed the profitability of black farming in order to protect white farmers from black competition and to assure the white farm sector of low-wage labor. The only areas where black farming was condoned were the homelands. Given their location, lack of infrastructure, and support services, generally poor soils, and extreme population pressure, it would be unfair to compare small-scale, farming in the homelands with farming in the white areas.

Nonetheless, a few cases exist in which small-scale farmers were given access to support structure roughly comparable to those of their white colleagues. The two case studies presented here, both in which small-scale, black farmers equaled or outperformed larger, white farms, come from tea and sugar farming.

In the tea industry, the case study illustrates that "mini-farming" (where an individual leases a small area planted to tea from a tea estate and is remunerated according to the quantity of acceptable tea produced) show an increase in yields, income, and profitability of both the estate renting out the land and the mini-farmers. Compared to ordinary pluckers, mini-farmers obtained yields on their 0.5 hectare plots averaging 23% more than what the large estate obtained (Van Zyl and Vink, 1992).

The same applies to the sugar-cane case study in the Eastern Transvaal, where black smallholders obtained 116.8 tons/hectare on their plots of 7.1 hectares (on average), while large-scale white farmers adjacent to these smallholders obtained 102.9 tons/hectare on 68.6 hectares (on average). Total costs amounted to R3 286/hectare for the smallholders and R3 448/hectare for the large-scale farmers (unpublished data from representative samples gathered by the University of Pretoria, 1993). Both these case studies confirm that with the same support structures small-scale farming is at least as efficient as large-scale farming in these specific areas and types of farming.

Evidence on Causes of Scale Efficiency

The official definition of the viable farm in terms of size has had a profound negative effect on the relative profitability of farms smaller than the viable size. Given the high levels of official assistance

and subsidies to farmers, the viability definition became almost a self-fulfilling prophecy, because under the Agricultural Credit Act all farms below the viable size were excluded from assistance. Moreover, under the Subdivision of Agricultural Land Act of 1970, it is not possible to subdivide an existing title deed without ministerial approval. Permission is granted only with proof that a reasonable net farm income can be obtained with "average" management. The subjectivity of this requirement, together with the lending criteria of the official funding agencies, precludes systematic empirical analysis of small farms in South Africa. Yet, it is interesting to observe that despite the lack of assistance for small farmers, official records of deed transfers show that the prices of small parcels of land increased more rapidly than the prices of large parcels since the 1960s.

Ironically, the benchmark for determining farm viability --farm size-- has changed over time; during the 1960s and 1970s, expansion and mechanization were considered the solution to remain competitive with non-farm incomes. However, in the 1980s, the high debt loads from capital and land purchases reduced farm profitability and decreased returns to capital-intensive investment. Thus many farms once thought to be viable by the criteria set in the 1970s were exposed as not viable in the financial crisis of the 1980s.

Farmers themselves seem to view consolidation of farms as a rational economic reaction capturing economies of scale. For instance, Moll (1988) reports that of 55 farmers surveyed in Bredasdorp and Malmesbury regions who had bought land during the previous decade, 35 (or 64%) indicated that they had done so partly to take advantage of size economies.

De Klerk (1991) attributes the process of farm consolidation to technical change, *viz.* mechanization. Consolidation has generally also caused a reduction in farm employment, because the new mechanized farm did not need to employ the workers from the more labor-intensive smaller farms that were acquired. While seasonal workers bore the brunt of mechanization, permanent workers were most directly affected by consolidation (De Klerk, 1985).

Sartorius von Bach, Van Zyl, and Koch (1992) constructed an index of managerial ability based on indicators such as budgeting and the keeping of records and found it to be highly correlated with both farm size and total farm income. By evaluating Cobb-Douglas production function coefficients with the managerial ability index included as an input, the authors found significantly increasing returns to scale among 34 farmers in Vaalharts Irrigation Area. When managerial ability is excluded from the regression, however, results indicate constant returns to size. These results are confirmed by Van Schalkwyk, Van Zyl and Sartorius von Bach (1993) using non-parametric procedures to analyze the same sample and adjusting

land size for quality differences. The same patterns hold true for a sample of 100 farmers in North-eastern Orange Free State.

Groenewald (1991) suggests that even beyond the indivisibility of capital and managerial inputs, economies of scale may result from scale efficiencies induced by the existing agricultural marketing system through volume discounts on the purchase of inputs and volume premiums on the sale of outputs. However, he ascribes most of the perceived economies of scale to management, with larger farms having better managers.

Roth, *et al.* (1992) econometrically tested a number of models explaining the reduction in the number of farms between 1972 and 1988. They found the number of farms to be positively correlated with the ratio of real machinery costs to real gross revenue, but negatively correlated with the ratio of farm requisites (mainly non-labor inputs) to output prices. This suggests that scale efficiencies in agriculture are strongly associated with a decline in machinery cost and an increase in the profitability of non-labor inputs. Both correlations suggest that the appearance of scale efficiencies in South African agriculture is rooted in the policy distortions that led to the reduction of the real cost of capital in the agricultural sector.

Chavas and Van Zyl (1993), using non-parametric analysis and accounting for quality differences in land, found a highly significant negative correlation between farm size efficiencies and debt burden, while size efficiency and managerial ability were positively correlated. The results show that the issue of scale efficiency is a complex one and is influenced by a variety of factors, of which managerial ability—the basic indivisible input in agriculture—seem to be dominant. A whole range of farm sizes both extensive and intensive commercial farming, was found to be scale efficient, depending on how farmers organize their specific variable and fixed input mix, as well as the combination of outputs they produce. Their results are consistent with the findings of Sartorius von Bach and Van Zyl (1992), who conclude that better managers have larger farms. It should be noted, however, that small farms will in general require less sophisticated management than large farms, which would explain why Chavas and van Zyl (1993) found efficient farms in all size categories. On the other hand, these results can be interpreted to mean that farm size is not really the central, but rather managerial ability.

Efficiency in the Former Homelands

The poor natural resource base and the continuous build up of demographic pressure since the beginning of this century through the racially segmented land, commodity, input and financial markets have made the homelands “functionally urban” or “rural dormitories”. Given these conditions, future

migrants from rural to urban areas are expected to come from the homelands; but even the steady out-migration from these areas will not exceed population growth (Urban Foundation, 1990).

It is difficult to get a grip on efficiency issues in the homelands; the existing data base is very weak and probably underestimates the importance of agriculture, even though it is extremely constrained by the overcrowded and poor resource base. For example, official estimates of homeland yields are consistently lower than case study data (e.g. Cairns, 1990).

However, the available case-study material does suggest that relatively few farmers are engaged in agriculture full-time in the homelands. According to Nicholson and Bembridge (1991), the majority of households in South Africa's homelands does not have enough land to provide for subsistence needs. Thus most rural households engage in farming only part-time, and most of their output is kept for consumption at home.

Several studies have also explored the relationship between farm size and efficiency in the homelands, where farms are in general much smaller than those in the commercial sector. Nieuwoudt (1991) notes that small farmers may use land much more intensively than do large farmers. Latt and Nieuwoudt (1988) used data on 140 households in Umbumbulu district of KwaZulu to conduct a discriminant analysis of input use. They found that farms of less than 1 hectare applied inputs much more intensively than farms larger than 1 hectare; thus they suggested that smaller farms may maximize returns to land (their scarce resource), while larger farms maximize returns to labor or capital.

Moreover, even in comparison with the commercial sector, homeland agriculture is sometimes found to be more efficient. Case study material shows that in dryland cotton smallholders in KwaZulu are more viable than large farmers (Wheeler and Ortmann, 1990:251). These trends are also confirmed by the two case studies mentioned earlier where small farmers, given the same support structures in tea and sugar farming, have done as well or outperformed larger farms (Van Zyl and Vink, 1992).

In a study of 60 farmers in Gazankulu, half of whom were identified by extension staff as commercially-oriented, Nicholson and Bembridge (1991) found that "commercial farmers" cultivate more land than "typical subsistence farmers" (12.2 hectares versus 2.3 hectares), own more cattle and equipment, are better educated, and more likely than their neighbors to keep records. Similar findings are reported for Transkei (Bembridge, 1991a), KwaZulu (Bembridge, 1991b; Wheeler and Ortmann, 1990; Nieuwoudt and Vink, 1989) and Lebowa (Van Zyl and Coetzee, 1990). The authors of these latter studies also note the importance of income from non-agricultural sources, such as wage employment, in providing working capital for the purchase of seeds, fertilizers, and other production inputs.

Given the lack of rights to buy and sell land, much of the increase in operational holdings by successful farmers represents formal or informal acquisition of temporary use rights held by others. Such transfers of temporary use rights may be consistent with improvement in efficiency, because they combine idle land with surplus labor and other factors. Such transfers are limited by the extreme population pressure under which the tenure arrangements operate. Landowners fear they will lose long-term rights to their land if they permit others to use it.

Synopsis

The evidence on the farm size-efficiency relationship in South African agriculture is mixed. However, much of the evidence on scale efficiencies in South African agriculture cited above, with only a few exceptions, should be interpreted with extreme care because data were not standardized for differences in land quality or labor productivity, or for the particular commodity mix of farms, and in some cases inappropriate analytical methods and measurement variables were used.

Evidence On Scale Efficiency In The Homelands⁶

The neglect of agriculture in the former homelands extends to the availability of information. The data for commercial agriculture is on a par with that for developed countries, and includes detailed time series for inputs and outputs dating from the end of the second World War. But for the former homelands there are a general paucity of data, with only sample survey data that is really reliable. Such data, collected for the Development Bank of Southern Africa, are analyzed in this section to establish farm size efficiency in these areas. These data are sufficient for estimation of efficiency of individual farms, which makes it possible to compare regions.

The organization of the rest of this section is as follows: the data is discussed next, while the methodology, including that of separating total from technical and scale efficiency, is discussed in the following sub-section. The last sub-section reports and interprets the results, comparing efficiency levels for the three homelands.

⁶ This section builds on analyses conducted by Piesse, Sartorius von Bach, Thirtle and Van Zyl (forthcoming).

The data were collected from three of the former homelands, KaNgwane, Lebowa and Venda, all in the northern or eastern parts of Transvaal. Detail on the physical characteristics of the regions and the role of farmer support programs (FSPs) can be found in Kirsten (1994).

A total of 23 FSPs were established by the Development Bank of Southern Africa (DBSA) in 1987 to provide participating farmers with services and training programs, and to identify and address the major constraints to agricultural production (Van Zyl, Fényes and Vink, 1992). All of the farmers in the sample used in this analysis benefited from the local FSP, either as current members or as previous members, and have benefited from some level of education and training. Many aspects of the programs are common to the three homelands, but one difference between the regions is the institutional arrangements for the provision of FSP services, since these are decided by the relevant homeland development corporation. However, the FSPs are similar to the extent that they all encourage the adoption of modern technology, including higher yielding varieties and chemical fertilizer (Singini, Sartorius von Bach and Kirsten, 1992). Extension and training relevant to new varieties and methods are also available.

The FSP data for KaNgwane, Lebowa and Venda cover the 1991 harvest, which is regarded as a normal year with respect to rainfall and yields. The original sample groups are shown in Table 2, but attempts to include numerous minor crops, that varied between regions, were hampered by the lack of price data, making comparisons difficult⁷.

Table 2: Population of Farms in Sample

Area	Total Number of Farm Households Surveyed	Households Producing only Maize	Current Members of FSP
Venda	60	30	27
Lebowa	84	64	56
KaNgwane	111	80	75
Total	255	174	158

Thus, the only farms retained were those for which maize production accounted for all of land utilization, and inputs were maize-specific inputs. This is considered to be acceptable since maize is by far the most important crop in the regions studied. Not surprisingly, labor was not reported as a crop-specific

⁷ These data include a range of socio-economic variables, since the original objective was to monitor farmer attitudes to the FSP initiatives. Only agricultural production is investigated in this paper, which is not intended, in any way, to be an evaluation of the FSPs. Special care was taken not to repeat the mistakes that abounds in the farm size efficiency literature (Binswanger, et. al, 1993), also in South Africa.

input. Therefore a labor variable was constructed, using the total area cultivated and total number of labor-days spent on agricultural activities, with a distinction between family and hired labor. The land variable was hectares planted with maize, with some adjustment for land quality differences. These were both small within regions and between regions, which is the major reason for selecting these three surveys for the analysis. Seed, fertilizer and other variable inputs were reasonably well recorded. In cases where seed input was very low or zero, and still some output was reported, it was assumed that seed had been kept from previous years (subsequent inquiries showed this to indeed be the case). Most farms reported using hybrid seed, except for Lebowa where a majority of farms used traditional varieties. Output was maize production in metric tons.

Thus, the farmers in the sample are maize producers, some of whom follow the FSP recommendations and use fertilizer and hybrid seeds, while traditional farmers do not use modern inputs (although also belonging to the FSP). For both outputs and some inputs --land and family labor-- there is no reliable price information and much of the maize is not sold, but is consumed within the household.

Table 3 illustrates the differences in performance of the three regions in the sample. KaNgwane has the largest farms and the highest average output, while the farms in Venda produce far less output. This is partly because the farms in Venda are smaller, but also because yields are far lower. Lebowa has the highest average yields, followed by KaNgwane. An important point is that the production potential of these three areas --as defined by soil quality and rainfall in the 1990/91 production season-- was essentially the same.

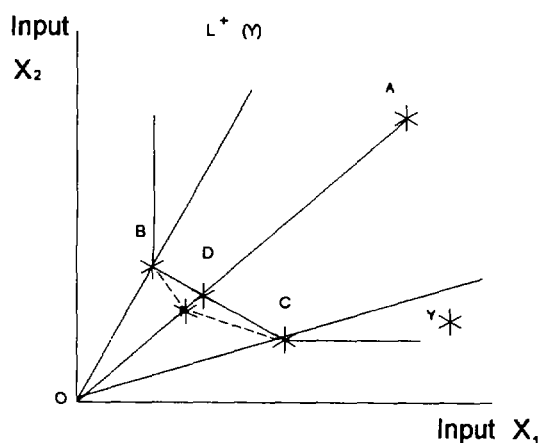
Table 3: Mean Output and Selected Inputs in Maize Production, 1991

Region	Output (kg)	Land (ha)	Yield kg/ha	Seed/ha (kg)	Fert/ha (kg)
KaNgwane	4,317	3.93	986	18.91	161.1
Lebowa	2,360	2.13	1,399	9.12	143.6
Venda	320	1.15	273	11.08	112.3

These basic statistics are useful, with yield being a partial productivity measure, considering the relationship of output to the input of land alone. On the other hand, measures of total factor productivity relate output to the aggregate of all inputs, giving a better indication of the overall efficiency of the system, and allowing the more advanced producers to be compared with the traditional farmers who use little in the way of modern inputs. Total factor productivity can be measured using the programming methodology discussed in the next sub-section.

The method used to measure efficiency in the homeland farms is data envelopment analysis (DEA).⁸ This uses a linear programming procedure to minimize inputs per unit of output, to determine the frontier of best-practice farms and then to determine the efficiency of all the production units relative to the frontier. This estimation approach is preferred to econometric modeling where the techniques impose a functional form and having a considerable number of zeros for some inputs can cause problems. The lack of price information limits econometric analysis to the estimation of production functions, precluding dual forms, such as the cost and profit function. Thus, the non-parametric efficiency measurement approach, that was introduced by Farrell (1957), is used here largely because it does not require prices and leads naturally to simple efficiency comparisons. The efficiency frontier is expressed in terms of minimizing the input requirements per unit of output. The Farrell technical efficiency measure is defined so that the isoquant, which is the locus of the efficient points using the minimum required inputs to produce the unit level of output. The efficiency of the other farms is measured relative to this isoquant, as Figure 1 shows.

Figure 1 : Farrel Efficiency Measurement

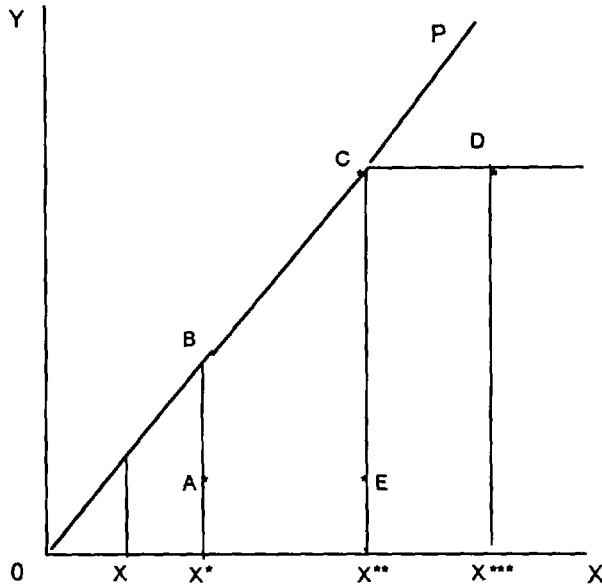


In the Figure, the efficiency frontier unit isoquant is determined by the linear combination of just two efficient farms, B and C, and is labeled Y^* . The efficiency of a farm such as A, that is not on the frontier, is measured by the ratio OD/OA , since OD is the vector representing the lowest mix of inputs which farm A could use and still reach the isoquant, using its own factor combination.

⁸ See Chavas and Aliber (1992) and Piesse, et. al, (forthcoming), amongst others, for descriptions and applications of the DEA methodology in this context.

The efficiency measures for 1991, which result from this analysis⁹ are reported in Table 4 of the next section. This is an assessment of aggregate, or total, efficiency, and includes both technical and scale effects, although these elements will be considered separately next. Since part of the current land reform policy in South Africa is based on the potential productive efficiency of small farms, it is important to measure the effects of farm size. Following Fare, Grosskopf and Lovell (1985), Figure 2 shows the effect of this decomposition.

Figure 2 : Decomposition of Technical and Scale Efficiency



In the Figure, the constant returns to scale (CRTS) technology is denoted by the linear total product curve, OP , from the origin, through the efficient production units B and C . Units A and D , in this example, are inefficient as they are below the CRTS frontier. When non-constant returns to scale are allowed for, the frontier is concave, and the input-output combinations A , B , C and D are all technically efficient.

When technical efficiency is extracted from total efficiency, only the scale effect remains. Thus, farm A is scale inefficient by OX^*/OX , due to being too small, but is technically efficient. Farm D is similarly technically efficient, but is too large and is scale inefficient by OX'''/OX'' . Finally, farm E is

⁹ The equations for the programming problem are fully stated in Piesse et al. (forthcoming).

technically inefficient by OX^{**}/OX^{*} and scale inefficient by OX^{*}/OX , giving a total level of inefficiency, relative to the CRTS frontier, of OX^{**}/OX .

Results and Interpretation

The objective of this section is to measure total efficiency and to separate the scale effects resulting from farms being an inappropriate size from the technical efficiency of farmers. The top row of results in Table 4 shows the mean efficiency levels for the three homelands, for the 1991 cropping year, decomposed into total, technical and scale efficiencies.

Table 4: Total, Technical and Scale Efficiency Levels - 1991 (Frontier=1.00)

Item	KaNgwane			Lebowa			Venda		
	Total	Tech	Scale	Total	Tech	Scale	Total	Tech	Scale
Mean Eff. by Region	0.358	0.703	0.487	0.427	0.794	0.547	0.476	0.671	.698
# Efficient	6	35	6	4	31	5	6	12	7
% Efficient	7.52	43.8	7.52	6.3	48.4	7.8	20	40	23.3
Mean Eff. Pooled Sample	0.250	0.637	0.394	0.372	0.828	0.485	0.069	0.740	0.113
# Efficient	3	35	3	1	38	1	0	11	0
% Efficient	3.75	43.75	3.75	1.56	59.38	1.56	0	36.7	0

The results are in agreement with the previous analysis of the survey data. These efficiency levels of the farms are calculated with respect to the best-practice farms within each region, which means that inter-regional efficiencies are not compared. For KaNgwane, the mean level of total efficiency, relative to the best practice farms is 35.8%, which is lower than for Lebowa (42.7%) or Venda (47.6%). As the most advanced and commercialized region, KaNgwane has greater variation in input levels than the two other regions, as Table 3 suggested. This is particularly true of farm size and the small farms in KaNgwane are scale inefficient, relative to the larger units, giving the lowest average scale efficiency of 48.7%. Conversely, Venda, which has the least variation in farm size, has a mean scale efficiency of 69.8%, which more than compensates for the low level of technical efficiency (47.6%) in the total efficiency calculations.

The next two rows show the number and percentage of farms that are on the efficiency frontier. For all three regions, at least 40% of the farms are technically efficient, but only a little over 7% are large enough to be scale efficient in KaNgwane and Lebowa, whereas 23.3% are scale efficient in Venda. Farms with a wide range of characteristics determine the frontiers. For KaNgwane, there are six efficient farms, which range in size from one to twenty hectares. Yields range from 0.19 to 4.6 tons per hectare, labor per

hectare from 0.05 to 2 persons, seed from zero to 18 kgs. per hectare and fertilizer from zero to 200 kgs. per hectare. The other regions have almost as great a range of efficient farms.

Figure 1 shows why this occurs. The farms that define the isoquant in the Figure are those that determine the extreme values of the factor ratios (OB and OC). Other farms will be included, and if there are enough efficient farms (such as F in the Figure) with more moderate factor ratios, then the isoquant will begin to approximate the smooth neoclassical shape (the dotted line BFC). However, the extreme values will always play an important role in DEA, in contrast to linear regression analysis, which tends to identify the characteristics of the average farm.

The isoquants for the three homelands have several dimensions, but the outstanding feature of the best practice isoquants can be described in the two dimensions of Figure 1. The two types of farm households that define the frontier may be called traditional and modern. If X_1 is taken to represent the traditional inputs (land and labor) and X_2 is modern inputs (hybrid seed and fertilizer), then the traditional farms can be represented by observations such as C in the Figure and modern farms, that have followed the FSPs advice, by points like B, with a much higher ratio of modern to traditional inputs¹⁰. Thus, the DEA does not provide direct comparisons of the farms that have adopted the FSP practices and those that have not. Both are technically efficient in Farrell's terms and further comparisons must be made on the basis of allocative efficiency, which requires price information¹¹. If an isocost constraint were to be added to Figure 1 (ignoring the hypothetical point F and the dotted frontier), C would be the allocatively efficient point¹² if the slope were less than that of the line BDC, meaning that modern inputs are expensive, relative to land and labor. If modern inputs were cheaper, relative to traditional inputs, then the isocost line could be steeper than BDC and B would be the economically efficient point. So, although technical efficiency can be analyzed without price information, some crucial economic comparisons cannot be made without price data.

However, DEA does go further in accounting for the efficiency differences, by separating the effects of farm size from pure technical efficiency. It seems that all three regions could considerably improve their efficiency levels if there were not constraints on farm size, but the importance of the scale issue is not apparent in the region-specific results.

¹⁰ In fact, the survey results are more extreme than this example; the most traditional farms use no improved seed and no fertiliser.

¹¹ The difficulty is the lack of prices for family labour and for land. There are prices for seed and fertiliser.

¹² The economically efficient point on the technically efficient isoquant.

The bottom half of Table 4 does compare between regions, by pooling the data and estimating inter-spatial efficiencies. In the fourth row, the efficiencies are calculated relative to a grand efficiency frontier, for the pooled sample of all three regions. There is no technical reason for not pooling the data for the three regions and measuring the efficiencies for the regions relative to a meta-efficiency frontier calculated from all the observations.¹³ The results of this approach show that fewer farms lie on the combined frontier than on the separate regional frontiers. This is inevitable, since as the sample size is increased by pooling, a farm's efficiency can only decrease, as its comparison set is augmented by new observations (Nunamaker, 1985).

The efficient farms are thus a subset of the regionally efficient units, with only three farms in KaNgwane and one in Lebowa remaining on the frontier. The three KaNgwane farms that were on the regional frontier and are not on the pooled frontier, were traditional producers, using few modern inputs. These are dominated by the one Lebowa farm on the pooled frontier, which claims to use no improved seed and no chemical fertilizer¹⁴. None of the three efficient KaNgwane farms are current FSP members, because they have evolved beyond the need for the FSP and are all large, commercial undertakings. However, they are following the FSP recommendations, in that they reach the frontier by achieving high yields, using heavy applications of modern inputs.

The most striking feature of the pooled efficiency results is the scale efficiencies. Whereas Venda appeared to have the highest level of scale efficiency, this result depended on the fact that all the farms are small. Once the small farms in Venda are compared with the larger units in the other two regions, none are scale efficient and mean scale efficiency falls to 11.3%, giving a mean total efficiency level of only 6.9%. Thus, these results suggest that the small farms in Venda, which average only 1.15 ha., are too small to be viable.

The input-based DEA analysis measures efficiency relative to a best practice isoquant, as shown in Figure 1, but as Ali and Seiford (1993) explain, this problem should be viewed as the first stage of a two stage model. Farms may be efficient, in terms of being on the frontier, but one or more variables may

¹³ Differences in land quality can be a problem when estimating meta-functions, and should be accounted for. In this case, the tree sample areas are relatively homogeneous both within and between regions. Furthermore, for the production year under consideration, rainfall and climatic conditions were, to a large extent similar. This is the reason for analysing these three surveys.

¹⁴ The reader does not need to believe that the figures for this particular farm are strictly accurate. It may, or may not, be possible to get 3,200 kgs. of maize per hectare without modern inputs in the most fertile parts of Lebowa; but if this farm were removed from the sample, there are several others very much like it, so the results are substantially unchanged.

be slack. If a variable is slack it is not acting as a constraint on production in the programming problem, so to be fully efficient, a farm should have no slacks. Of the farms on the efficiency frontiers for the three regions, all but one are also fully efficient, in the sense of no variables being slack. For the farms that are not on the frontier, all have one or more slack variables, so the slacks provide an indication of the inputs that are in excess supply and those that are effectively constraining production. The results for Lebowa are perhaps the most enlightening; land is the main constraint, effectively limiting output for the vast majority of the farms, while at the other extreme, fertilizer was in this sense surplus to requirements for a large number of the farms. For Venda, seeds appear to be a binding constraint for the majority of farms, while a large number had an excess of fertilizer. Land appears to be slack for many farms, but this result should be disregarded, due the problem of lack of variance of area planted in Venda. KaNgwane is far more mixed, with land being the most common constraint on production, and labor the least common.

Conclusions

This section uses recent farm-level data to study the regional differences in maize production efficiency in the former homelands. Non-parametric techniques allow estimation of total productive efficiency in the absence of prices, or when this data is unreliable. Regional differences do occur, and may be due to land quality variation, but the scale inefficiencies noted in Table 4 have implications for addressing the skewed distribution of land ownership in South Africa (Van Zyl, Van Rooyen, Kirsten and Van Schalkwyk, 1994). Relatively large efficiency gains can be achieved by redistributing other land to some farmers, in order to increase farm size in the homelands.

Economies Of Scale In Commercial Agriculture

As noted in earlier, the majority of the previous studies on the farm size-efficiency relationship in South Africa are flawed due to a variety of reasons, and the results are therefore not reliable. In particular, the studies generally suffer from the following shortcomings: only a minority of the studies adjust farm size for quality differences in land and other inputs; most of the studies use physical yields of specific crops or the value of agricultural output per unit of operated area, both imperfect (and at best only partial) measures of efficiency; differences in operational holding size and ownership holding size are sometimes not accounted for; and managerial inputs from the farmer and his/her family, and family labor, have not been included.¹⁵

¹⁵ See Binswanger, *et. al* (1993) for a discussion of these problems, as well as appropriate measures of farm size efficiency.

This section makes use of three different methodologies to determine the farm size-efficiency relationship in commercial agriculture: first, total factor productivity differences between small and large farms are determined; second, non-parametric Data Envelope Analysis (DEA) is used to estimate scale efficiencies; and third, following the suggestions of Binswanger, *et. al* (1993), regression analysis is used to test the farm size-productivity relationship.

Data

The data used in these analyses come from farm surveys conducted by the Department of Agriculture's Directorate of Agricultural Economics over the period 1974/75 to 1990/91. Farm surveys, covering a representative sample of between 65 and 85 individual farmers, were conducted in each of the six major grain production areas of South Africa. Two regions were surveyed per annum, implying that each region was surveyed every three years. These six areas involve rain-fed agriculture; subsequently, an irrigation area was also included in the analysis. The regions included in the analysis are representative of the relatively medium and high potential agricultural areas of South Africa, excluding perennial crops. More than 80 percent of all maize, wheat and other grain are produced in these areas, while livestock (dairying, beef cattle and woollen sheep) is also important in most areas. Table 5 provides more information on the surveys included in the analyses. They were selected to represent all the regions; poor, normal and good rainfall years; thus, selected years during the period 1974 to 1991.

The data from these surveys specifically allow for the elimination of the problems with previous studies. In particular, farm size is adjusted for differences in land quality within regions by using land value to normalize areas; differences in operational holding size and ownership holding size are incorporated into the analysis; and family labor is considered. Another important point is that, within a specific region, all farmers essentially face the same prices because they buy from the same input suppliers and output markets for most commodities were controlled. This implies that monetary values of outputs and inputs (revenues and costs in the relevant categories) can be treated as quality adjusted quantities,¹⁶ which greatly enhances the reliability of the analysis as it also normalizes input and output quantities by

¹⁶ This amounts to assuming that the corresponding implicit price indexes are unity. This approach has the advantage of being empirically tractable. Although it allows for price variation across years and areas, it has the disadvantage of neglecting price variations across farms within any particular survey. While the intuition is that these variations are small or even negligible, they cannot be ruled out. The "rule of one price" (Chavas and Aliber (1992) does, for example, not take into account different transaction costs or market failures. However, the assumption that all farmers within a survey face the same prices seem to be reasonable given the nature of the farm support system in these areas. An additional, but related point is that the "rule of one price" implicitly accounts for commodities which are not of homogeneous quality. Different farmers may face different prices because they purchase inputs or sell outputs of different quality. By using the monetary values of input and output as quantities, there is an adjustment for these quality differences, with an implicit assumption that the markets work fairly well.

eliminating the effect of quality differences. The opportunity cost approach was used to derive the value of family labor.

Table 5: Surveys included in the farm size-efficiency analyses of commercial farming

Region	Type of Farming (Predominant)	Year Covered by Survey	Number of Farmers Surveyed
Eastern Free State	Summer-rainfall (mixed): maize, wheat, cattle, sheep	1979/80	92
		1982/83	83
		1985/86	76
		1988/89	72
Transvaal Highveld	Summer-rainfall (mixed): maize, sorghum, cattle, sheep	1974/75 1983/84	71 77
Western Transvaal	Summer-rainfall (grain): maize, sunflower, cattle	1981/82	78
North-western Free State	Summer-rainfall (grain): maize, wheat, sorghum	1979/80	87
Ruens	Winter-rainfall (mixed): Wheat, sheep, dairying	1978/79 1987/88	69 77
Swartland	Winter-rainfall (mixed): Wheat, sheep, dairying, beef	1983/84	82
Vaalharts	Irrigation (annual crops): wheat, cotton	1990/91	34

All analyses were conducted separately for each region/survey. Because the analysis implicitly neglects possible production uncertainty (for example due to weather effects), the underlying assumption is that all farmers within each survey face similar production uncertainty. This seems to be appropriate given that the analysis is conducted for a given production year and one relatively homogeneous region at a time.

Table 6 provides a summary of the size characteristics of the farms in each of the surveys. From this information it is clear that the surveys cover a relatively large range of farm sizes. While relatively small farms are also part of the data set, the average farm size indicates that the farms are in general large, specifically relative to world standards. The median farm size is smaller than the average in all the data sets, indicating a positively skewed size distribution.

The final data for each farm in the different samples involve inputs and outputs. These were aggregated to give two output series -- crops and livestock -- and seven input series --land, buildings, livestock and machinery represented the stock inputs, while labor, management (including family labor) and variable inputs¹⁷ represented flows. All quantity measurements used in the analysis were annual flow variables. The stock variables were transformed into flow variables by calculating the equivalent annuities

¹⁷ Variable inputs represented all the other inputs, including seed, fertiliser, purchased animal feed, chemicals, etc.

based on the relevant interest rate for that period and region, the average useful life of the particular assets, and the applicable tax rate.¹⁸ Thus, the analysis presented below measures all inputs and outputs as annual flows expressed in monetary values.

Table 6: Summary size characteristics of farms analyzed (adjusted ha)

Region	Year	Farm Size Characteristics (ha) - Adjusted for quality differences			
		Average	Median	Maximum	Minimum
Eastern Free State	1988/89	993.2	763.0	3418	32
	1985/86	1375.4	943.7	9221	108
	1982/83	1154.8	885.5	4287	41
	1979/80	1019.5	860.4	2504	162
Transvaal Highveld	1983/84	1101.2	933.7	3394	178
	1974/75	663.4	464.9	3716	107
North-western Free State	1979/80	865.4	767.8	2355	158
Western Transvaal	1981/82	474.6	361.5	1461	118
Ruens	1987/88	1501.0	1167.3	6638	230
	1978/79	1435.3	1054.2	4706	187
Swartland	1983/84	793.4	704.5	2675	259
Vaalharts	1990/91	50.4	50.4	97	17

Total Factor Productivity by Farm Size Category

Total factor productivity (TFP) for different farm size categories is clearly a superior indicator of the farm size-efficiency relationship when compared to partial indicators, such as physical output or value of agricultural output per unit of operated area, as it fully accounts for differences in labor and input use. In this sub-section, TFP values for different farm size categories are compared for each of the surveys in table 5. The Tornquist-Theil Index was used to calculate the comparative TFP index, while the farm with the highest TFP --the most efficient farm-- was used as reference point in these calculations.¹⁹ The methodology in constructing the TFP index is described in detail in Thirtle, *et al* (1993). Table 7 presents the results.

¹⁸ To convert the stocks, namely land, buildings, livestock and machinery, into annual flows, discount rates for these inputs based on the economic rate of depreciation (5 years for machinery and 20 years for buildings), the national price indices, the interest rate on the relevant annuities and the pertinent tax rate were calculated and multiplied by the market value of each asset.

¹⁹ See Ball, Bureau and Butault (1994) for a review of the properties and recommendations on the selection of different index numbers based on the axiomatic and economic approaches. Following from this, the Tornquist-Theil methodology is appropriate for this analysis.

Table 7: Relative total factor productivity and labor/machinery indices for different farm size categories*

Region	Year	Total Factor Productivity**			Labor/Machinery Ratio**		
		Small	Medium	Large	Small	Medium	Large
Eastern Free State	1988/89	129	126	100	192	113	100
	1985/86	115	107	100	136	116	100
	1982/83	104	101	100	115	106	100
	1979/80	102	99	100	129	98	100
Transvaal Highveld	1983/84	111	104	100	138	128	100
	1974/75	113	110	100	115	110	100
North-western Free State	1979/80	117	111	100	135	95	100
Western Transvaal	1981/82	103	91	100	122	91	100
Ruens	1987/88	128	110	100	125	97	100
	1978/79	112	110	100	132	92	100
Swartland	1983/84	106	102	100	118	104	100

Note: * Three farm size categories were defined for each data set: small represents the smallest third of the farms; medium represent the middle third of the farms; and large represents the largest third of the farms.

** TFP index and labor capital ratio of large farms are the norms (100) against which the other size categories were compared.

Both the results on total factor productivity and the labor/machinery ratio per farm size category are enlightening when considering land reform (Table 7). Within the sample of relative large commercial farms, covering a range of farms sizes which all depend heavily on hired labor, the results are clear:

- It establishes that the negative relationship between farm size and efficiency also applies to South African commercial farming areas, in spite of a history of distortions and privileges to these farmers which particularly benefited the larger ones. Without exception, the relative TFP index of the smallest third farms is higher than that of the largest third farms. Efficiency gains are highest in the Eastern Free State for 1988/89 and 1985/86, where the small farms performed respectively 29 percent and 19 percent better than the large farms, and the Ruens for 1987/88, where small farms fared 28 percent better. While these differences are in most cases not statistically significant at the 10 percent level (with the exception of the three cases cited above) due to the wide variation of results between farms within a particular region, smaller farms are in general more efficient than larger farms.
- Furthermore, it seems that this negative relationship became more accentuated after 1985, when the movement towards the removal of distortions and abolishment of privileges to larger farms started taking effect. The three data sets covering the period after 1985 all yielded statistically significant differences (at the 10 percent level) in efficiency between small and large farms, while all the data

sets covering farm operations before 1985 yielded statistically insignificant differences (at the 10 percent level). This aspect needs further investigation to fully confirm these observations. However, the result is fully compatible with prior expectations.

- Smaller farms consistently have a higher labor/machinery ratio than larger farms in all the areas for all the periods covered, indicating that they are relatively more labor intensive. Differences between these ratios are statistically significant between small and large farms for most of the areas at the 10 percent level of significance (with Eastern Free State in 1982/83, Transvaal Highveld in 1974/75, and Swartland in 1983/84, being the exceptions).

The conclusion thus is that, in general, smaller farms are not only more efficient than their larger counterparts, but are also relatively more labor intensive in their mode of production. However, these general results derived from averages within groups mask the wide variability between specific farms. Figures 3 and 4 provide an indication of this variability, respectively in the Ruens (1978/79) and the North-western Free State (1979/80). From these figures it is obvious why efficiency differences between small and large farms were not statistically significant for these two areas.

Figure 3: Farm Size-Efficiency in the Ruens, 1978/79

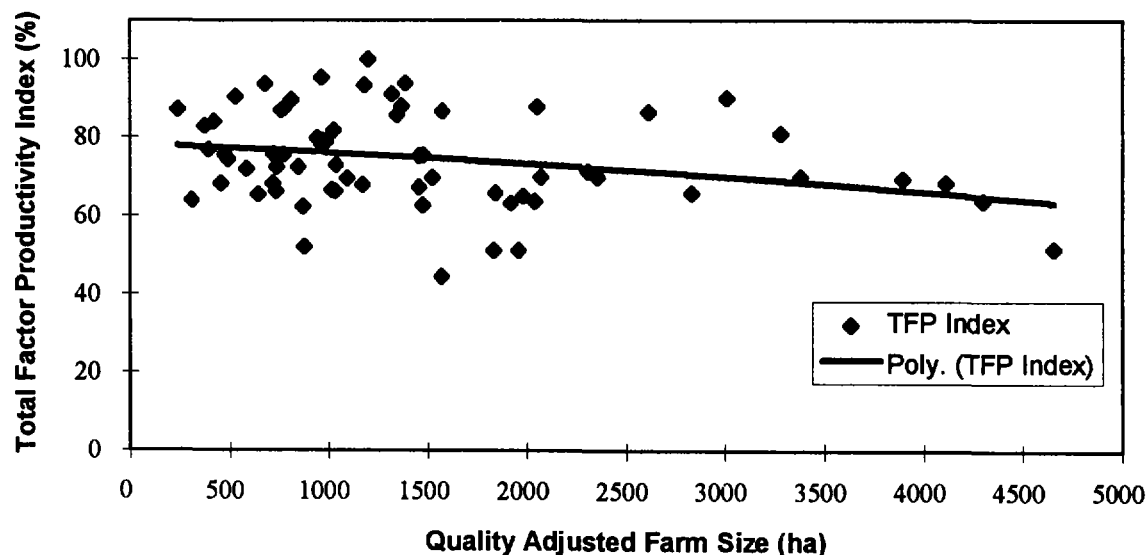
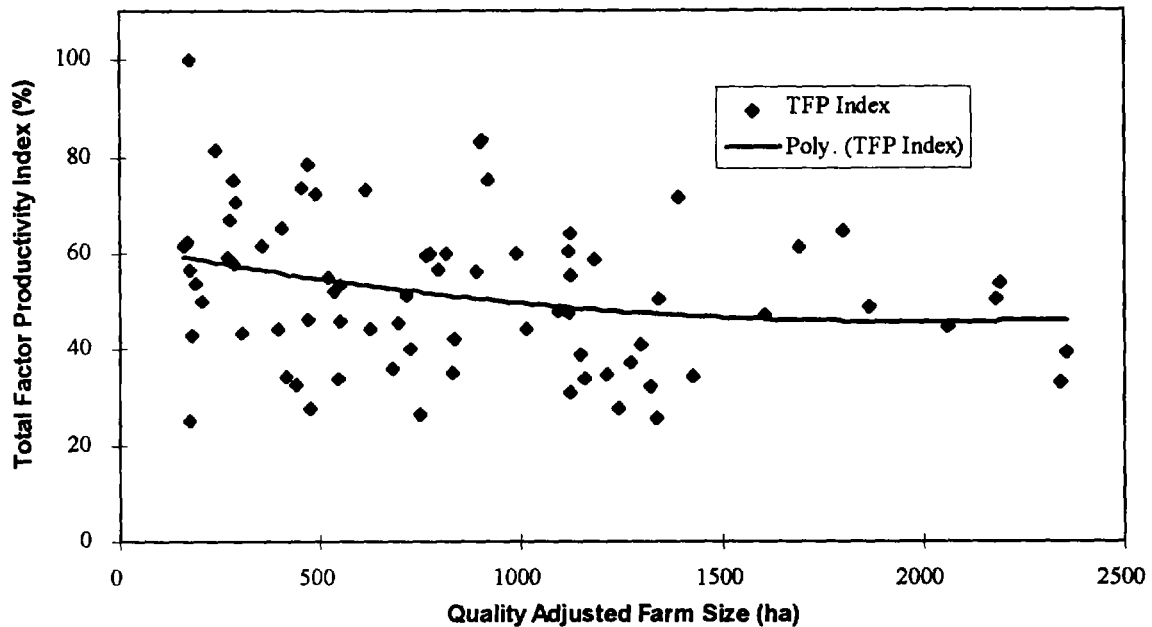


Figure 4 : Farm Size-Efficiency, Northwestern Free State, 1979/80



Using market prices to measure productivity assesses differences in private efficiency, while the use of social opportunity costs as a measure eliminates the impact of distortion and measures differences in social efficiency. Few studies, none of them in South Africa, has made this distinction in the analysis of the farm size-efficiency relationship. During the period under consideration, the price of capital was distorted by several factors, including tax benefits and interest rate subsidies. This contributed, amongst other things, to over-capitalization of specifically larger farms (see table 7). On the other hand, output prices were also distorted due to protection and market price support.²⁰ Most of these privileges went to relatively large farms. Accounting for these distortions is thus important when looking at farm structure and production relations from a social point of view.

Social efficiency estimates were calculated for four of the data sets analyzed above, namely Eastern Free State (1988/89) and Ruens (1987/88), as well as Western Transvaal (1981/82) and Eastern Free State (1979/80). These four surveys respectively represent those with the two largest differences and two smallest differences in average TFP between small and large farms in table 7. Alternatively, they can also be regarded as representative of the beginning and the end of the decade of the 1980s -- thus pre-reform and just after the first reforms started taking effect. They are also representative of all the areas in the analysis. Social opportunity costs for capital, labor, variable farm inputs and farm outputs (both crops

²⁰ See Van Zyl and Groenewald (1988) and World Bank (1994) for a synopsis of these policies and their effects.

and livestock) were obtained from previous studies and were incorporated into the analysis.²¹ The TFP analysis of each farm was repeated using these social opportunity costs rather than the actual private costs. The results of these social efficiency estimates are summarized in table 8.

Table 8: Social relative total factor productivity for different farm size categories*

Region	Year	Average Social/Private TFP ratio	Social Total Factor Productivity**		
			Small	Medium	Large
Eastern Free State	1988/89	0.86	138	133	100
Ruens	1987/88	0.91	135	108	100
Western Transvaal	1981/82	0.78	118	85	100
Eastern Free State	1979/80	0.75	121	97	100

Note: * Three farm size categories were defined for each data set: small represents the smallest third of the farms; medium represent the middle third of the farms; and large represents the largest third of the farms.

** TFP index and labor capital ratio of large farms are the norms (100) against which the other size categories were compared.

The results from the social TFP analysis should be interpreted with care. Farmers react to the incentive structure facing them, and if capital are relatively cheaper, they should use more of it, and vice versa. For this reason the social TFP calculations are more indicative of the distortions than the actual social costs or efficiency losses. Strictly, changing the values from private to social prices does nothing to the physical input and output ratio, and TFP stays essentially the same, although the weighting of the inputs and outputs change. However, the point here is to determine to what an extent farm size influences the farmer's ability to capture benefits and use the structure of incentives. The results obtained from the social TFP analyses, which are summarized in Table 8, indicate that:

- Average social TFP is lower than average private TFP in all the regions. The difference is much more accentuated at the beginning of the 1980s than later in the decade when some of the privileges were already removed. The reason for this is that because all farmers face the same prices, the value of outputs and inputs can be treated as quality adjusted quantities. While these differences are meaningless in terms of efficiency, they indicate to what an extent policies have been distorted.
- Larger farms are less efficient relative to smaller farms when social opportunity costs are used to determine the value of output instead of actual market prices. The reason for this stems mainly from the differences in the relative importance of labor and capital in the input mix of large and small farms (see table 7). The value of output of small and large farms are generally affected in a similar

²¹ See, for example, Helm and Van Zyl (1994), Van Heerden and Van Zyl (1992) and Meyer and Van Zyl (1993).

manner because the ratio of livestock to crops does not differ significantly between these groups, but the input mix varies considerably, with large farms being relatively more capital intensive and small farms being relatively more labor intensive. Because the social opportunity cost of labor is lower than the actual wage rate (due to massive rural unemployment), and the higher social opportunity cost for capital than the subsidized prices farmers face, the total value of inputs increase more for large farms than for small farms.

- The positive effects of removal of distortions on small farms (or negative effects on large farms) are relatively greater where the distortions have been large. For example, the analysis show that small farms gain more in relative efficiency (compared to the private analysis in table 7) under such situations.

Non-parametric Efficiency Estimation Using Data Envelope Analysis (DEA)²²

The analysis of efficiency has fallen into two broad categories: parametric and non-parametric. The parametric approach relies on a parametric specification of the production function, cost function or profit function (see, for example, Forsund et al, 1980; Bauer, 1990). Alternatively, production efficiency analysis can rely on non-parametric methods (see, for example, Seiford and Thrall, 1990). Building on the work of Farrell (1957) and Afriat (1972), the non-parametric approach has the advantage of imposing no a priori parametric restrictions on the underlying technology (see, for example, Färe et al, 1985). Also, it can easily handle disaggregated inputs and multiple output technologies. As the non-parametric approach develops, its applications to production analysis have become more refined (Chavas and Aliber, 1993). This provides some new opportunities for empirical analysis of economic efficiency. This sub-section uses this non-parametric or DEA approach (similar to the analysis of efficiency in the former homelands) to estimate the farm size-efficiency relationship in the Eastern Orange Free State (1979/80, 1982/83, 1985/86 and 1988/89) and the Vaalharts irrigation area (1990/91). In particular, the scale efficiency of each of the farms is determined relative to that for the whole data set.

Non-parametric scale efficiency (SE) measures were developed in response to the earlier work on technical efficiency (TE) and allocative efficiency (AE) (see Baumol, et. al, 1982). While TE and AE take the output level as given, SE is concerned with choosing the output level itself. The key question becomes whether firms are operating under decreasing, increasing, or constant returns to scale. The SE takes on values between 0 and 1, where SE=1 identifies scale efficiency under (local) CRTS. Finding SE<1 means

²² The non-parametric analysis of efficiency benefited from discussions with and suggestions by Jean-Paul Chavas from the University of Wisconsin-Madison. The GAMS code for the initial analysis was provided by him, while Paula Despins did some of the initial calculations.

that the firm is not scale efficient, i.e. does not produce at a scale exhibiting local CRTS. In this context, (1-SE) can be interpreted as the relative decrease in average cost obtainable from rescaling outputs to the point of (locally) constant returns to scale. Tables 9 and 10 provide the results for the Eastern Orange Free State (all four surveys).

Table 9: Summary of Efficiency Results, Eastern Free State (1.00=efficient)

Efficiency	Year	Average	St Dev	Median	Mode	Min	Max
Technical (TE)	1979/80	0.85	0.23	0.91	1.00	0.38	1.00
	1982/83	0.85	0.18	0.91	1.00	0.38	1.00
	1985/86	0.90	0.15	1.00	1.00	0.39	1.00
	1988/89	0.89	0.16	1.00	1.00	0.48	1.00
Scale (SE)	1979/80	0.87	0.23	0.93	0.98	0.24	1.00
	1982/83	0.84	0.14	0.89	1.00	0.51	1.00
	1985/86	0.79	0.21	0.86	1.00	0.08	1.00
	1988/89	0.83	0.16	0.88	1.00	0.33	1.00
Allocative (AE)	1979/80	0.73	0.23	0.72	1.00	0.21	1.00
	1982/83	0.74	0.17	0.76	1.00	0.25	1.00
	1985/86	0.78	0.15	0.78	1.00	0.39	1.00
	1988/89	0.66	0.20	0.66	1.00	0.30	1.00

Table 10: Average farm size of efficient versus inefficient farms (scale, technical and allocative efficiency), Eastern Free State (ha)

Item*	1979/80	1982/83	1985/86	1987/88
SE-eff	1208.3	766.4	697.3	475.3
SE-ineff	1369.3	1349.1	1624.6**	1221.8
TE-eff	1265.2	1205.3	1312.1	1226.5
TE-ineff	1283.9	1293.9	1329.7	1215.4
AE-eff	1258.2	1246.3	1285.1	1387.3
AE-ineff	1267.5	1253.2	1309.4	1188.8

Notes: * SE = scale efficiency, TE = technical efficiency, and AE = allocative efficiency
 ** The average is relatively high due to two very large farms

The results are, to a large extent, similar to those obtained with the TFP analyses. In addition, the methodology used here isolates scale efficiency from technical and allocative efficiency, while TFP measurements do not differentiate between them. The results yielded statistically significant differences between average farm sizes of scale efficient (SE-eff) and inefficient (SE-ineff) farms ($p < 0.10$) for 1982/83, 1985/86 and 1988/89. No similar trend was encountered for technical efficiency (TE) and allocative efficiency (AE), implying that there is no meaningful relationship between TE or AE and farm size. This implies that the farm size-efficiency relationship has its origin in scale efficiency and not

technical or allocative efficiency. While technical and allocative efficiency does not differ significantly across farms sizes, scale efficiency does differ significantly.

The conclusions are as follows:

- Differences in scale efficiency are relatively more important in explaining efficiency differences between small and large farms than differences in technical or allocative efficiency.
- These results even more clearly establish an inverse relationship between farm size and efficiency.
- Another trend which emerges from these results, which also confirms the previous observations, is that the average farm size of efficient farms declined over time. This correlates with the abolition of tax and credit policies favoring relative large farmers more than small farmers.

In order to identify where and why the diseconomies of scale set in, the inverse of the SE measure was investigated. Following Chavas and Aliber (1993), this inverse can be interpreted as something akin to an average cost function, i.e. it is a declining function of outputs under increasing returns to scale (IRTS) and an increasing function of outputs under decreasing returns to scale (DRTS). In all years, there is very little difference between the average scale inverses for the largest 25% of the farms. Between the largest 10% and the rest, however, there are diseconomies of scale emerging in most years. It appears to be largely driven by diseconomies of scale in crop production with very little noticeable difference between farm sizes and the inverse for livestock production, which is mostly extensive ranching. As most farms derive a very large percentage of their gross farm income from crop production, this would appear to explain the low number of perfectly efficient farms. Given that only 10% of the farms are exhibiting strong diseconomies of scale, the relatively reasonable performance of individual farms is also not surprising.

The analysis of scale efficiency in the Vaalharts irrigation area differs in two complementary ways from the above analyses:

- farm sizes are much smaller in the Vaalharts irrigation area than in the grain producing regions (table 6); and
- scale efficiency is also related to farmer's managerial ability (apart from quality adjusted farm size) in the Vaalharts area.

Managerial skill in the Vaalharts area was measured explicitly according to the method proposed by Burger (1971), who developed and validated a scale of 'managerial aptitude' of farmers. This scale is based on six different factors: vision, planning, record keeping, labor management, budgeting and maintenance tasks. This scale was found to be positively associated with size related variables, including farm size, and return to assets (Groenewald, 1991; Van Schalkwyk, *et. al.*, 1993; Sartorius von Bach and van Zyl, 1992).

Scale efficiency of the individual farms in the Vaalharts area was determined using the DEA methodology described earlier.²³ Figures 5 and 6 present the results of the analysis by plotting the inverse of the scale efficiency index (1/SE) against quality adjusted farm size and managerial ability. This inverse (1/SE) can be interpreted in a way similar to an average cost function: (1/SE) is a decreasing function of outputs under increasing returns to scale, and an increasing function under decreasing returns to scale.

Figure 5 shows that a whole range of farm sizes is efficient, from the smallest to the largest. However, there is evidence of economies of scale for very small farms, with the majority of inefficient farms being on the small side. This result differs from the previous findings where no economies of scale were found. However, farm sizes in Vaalharts are much smaller, making supervision of labor easier and less expensive. On the other hand, machinery is the slack variable for many of the small farms that are scale inefficient. Indivisibility seems to play some role here, particularly with respect to tractors. To perform the necessary tasks on even the smallest farms in the sample, at least two tractors are required, as some of the tasks has to be performed simultaneously. While combine harvesters and other large machinery can be contracted or hired, this is not possible for tractors within the present farm support structure. Two small tractors can work areas of up to 50-60 ha easily if managed properly; therefore, the lumpy input argument seems to apply for small farm sizes. But, this argument applies only to some farms: roughly one third to one half of the small farmers are scale efficient. Upon further investigation it seems that these farm managers found a way around the lumpy machinery input problem by entering into sharing arrangements and/or diversification of their operation to minimize the need for simultaneous use of machinery. Management seems to be important in this respect.

²³ The procedure is similar to that used by Chavas and Aliber (1993) who analysed efficiency of grain and dairy farmers in Wisconsin.

Figure 5 : Farm Size-Efficiency in the Vaalharts Irrigation Area, 1990/91

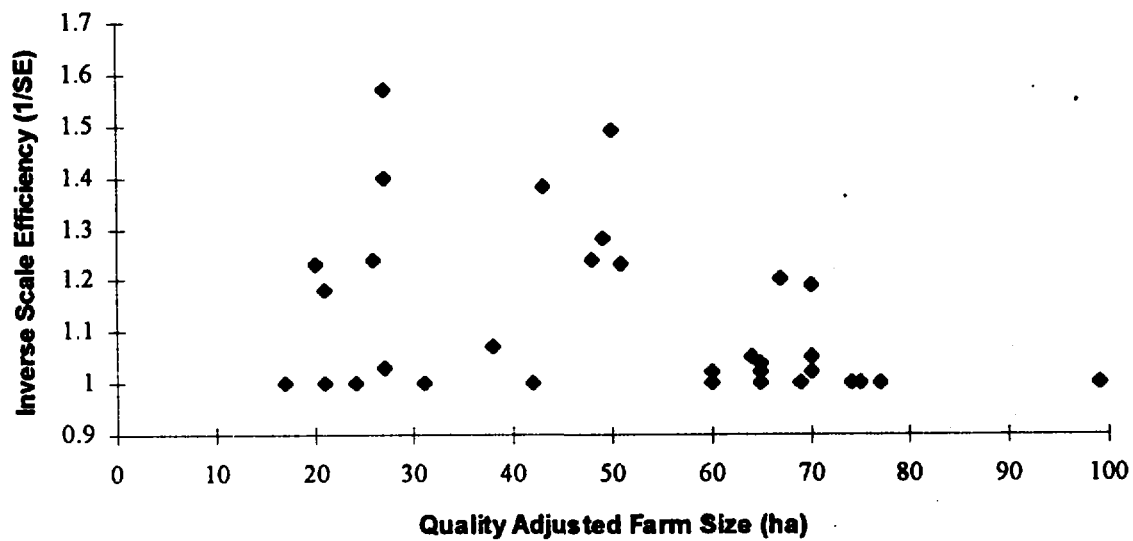


Figure 6 : Managerial Ability and Farm Size, Vaalharts (1990/91)

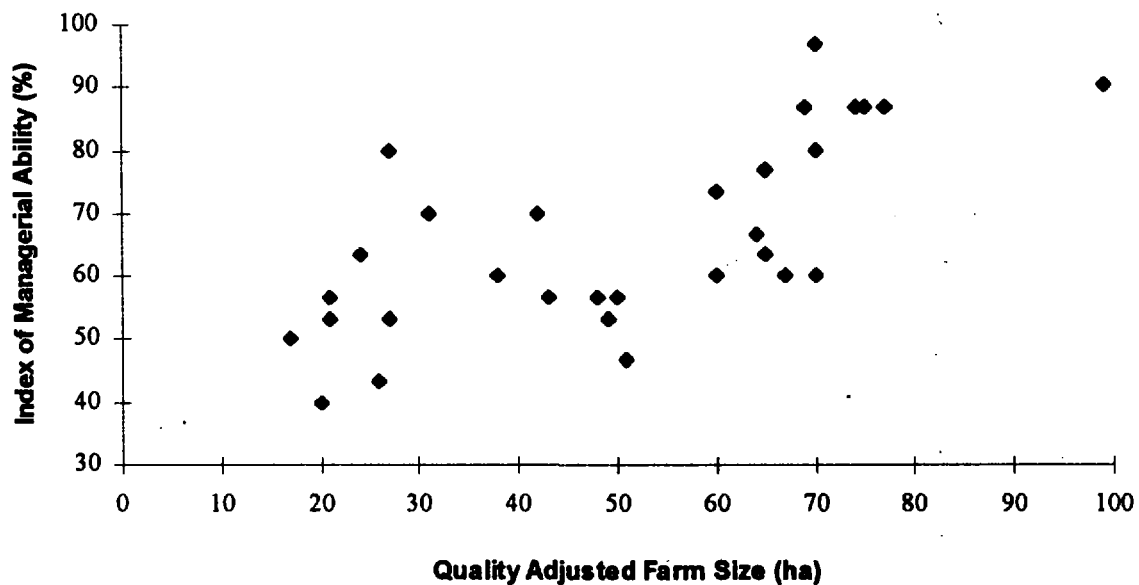


Figure 6 establishes a strong relationship between scale efficiency and managerial ability. For example, managers with better managerial ability are generally more scale efficient. This relationship is also statistically highly significant: the correlation coefficient between farm size and inverse scale efficiency is -0.334 ($p=0.062$);

between managerial ability and inverse scale efficiency is -0.589 ($p < 0.0001$); and between farm size and managerial ability is 0.686 ($p < 0.0001$).

Results obtained from the analysis are mixed, and clearly demonstrates the complexity of the issues involved. A whole range of farm sizes seems to be scale efficient (figure 5), depending on how farmers organize their specific variable and fixed input mix, as well as the combination of outputs they produce. In this respect a number of relatively small farms are scale efficient, although there seems to be a bias towards a larger number of relatively small farms being scale inefficient. On the other hand, the relationship between scale efficiency and managerial ability seems to be much stronger. This emphasizes the importance of management: results support the notion that better managers operate on larger farms than less skilled managers.²⁴ In this respect, Groenewald (1991) is of the opinion that “returns to management” is a more appropriate concept than returns to scale.

Econometric Estimation of the Farm Size-Efficiency Relationship

Another appropriate way in which to measure relative efficiency of small and large farms is to investigate the difference in profits, net of the cost of family labor, per unit of capital invested Binswanger *et al*, 1993). The following test of the farm size-productivity relationship, proposed (and discussed) by Binswanger, *et al* (1993), was used to take most of the methodological considerations into account:

$$P/K = g(OP, OW, H, Z) \text{ with expected signs } g_1 < 0; g_2 > 0; \text{ and } g_3 > 0; \quad (1)$$

where K is assets, L is labor, P is private or social profits net of private or social cost of family labor, OP is operated area or value of operated land, OW is owned area or value of owned land, H is the number of household workers, and Z is a vector of exogenous land quality, distance from infrastructure, and land improvement variables. Also, g_1 should be negative because of rising supervision costs; g_2 should be positive because ownership provides better access to credit; and g_3 should be positive because family members have incentive to work and can supervise. Equation 1 does not describe a casual relationship, but a multiple correlation.

In addition to this specification, managerial ability of the farmer (M) is an important explanatory variable which needs to be considered. This clearly also impacts on efficiency (see results of DEA analysis) and because it varies for different farms, it should also be included as part of the multiple correlation depicted by equation 1.

²⁴ This result is consistent with earlier findings reported by Van Schalkwyk, *et al* (1993) for Vaalharts, and Sartorius von Bach and van Zyl (1992) for the Aberfeldy district in the Eastern Free State.

The equation was estimated for only Ruens in 1987/88 and the Vaalharts area in 1990/91. These surveys included information which allows for specification of the variables in equation 1, with some adjustments to capture the specific set of circumstances particular to the local situation. The specification of P/K and OP in equation 1 is straight forward from the available data. Most of the land is owned by the operator, with the results that OW is correlated with OP. To avoid estimation problems, OW was specified as the percentage of land owned by the operator. Due to the situation in South African commercial agriculture, H was specified not as the number of household workers, but as remuneration of management (including the owner and household members, and people other than that of the owner which benefit from revenue sharing arrangements)²⁵ expressed as a percentage of other (hired) labor costs. Lastly, Z was specified as the fixed land improvements per unit area, because most of the other land quality characteristics were already considered when adjusting farm size for land quality differences.

In addition, the estimation for Vaalharts was done both with and without inclusion of managerial ability (M) as independent variable in equation 1. The argument for inclusion is similar to that for incorporating differences in land quality. The estimation of equation 1 assumes that all factors not specified are fixed and similar for all farms. Factors which differ between farms, and may have an influence on the results (such as managerial ability), should therefore be accounted for explicitly. In this respect the intuition is that the coefficient of M should be positive, as better managers should get a higher return on their investment.

Table 11 shows the results of the regression analyses which were used to determine the relationship between profit (net of family labor) per unit of investment, and the other variables.

²⁵ This approach in essence broadens the concept of family members engaging in and benefiting from supervision tasks. Only a relatively small number of farms (16%) had a value other than zero for H.

Table 11: Results of the Regressions on Farm Size-Efficiency in Vaalharts, 1990/91

Regression/ Region	Variables					Equation	
	OP	OW	H	Z	M	F Value	Adj R ²
Ruens	-0.0067 (0.093)	0.0233 (0.114)	0.0142 (0.223)	0.0025 (0.002)	-	45.28 (0.000)	0.62
Vaalharts1	-0.0428 (0.259)	0.0574 (0.008)	0.0811 (0.042)	0.0002 (0.2875)	-	37.53 (0.000)	0.55
Vaalharts2	-0.0735 (0.182)	0.0239 (0.094)	0.0756 (0.066)	0.0001 (0.365)	0.0533 (0.050)	74.25 (0.000)	0.69

- Notes:**
- 1) Value in brackets indicates the significance of the coefficient or value.
 - 2) R² of a regression model without an intercept measures the proportion of variability in the dependent variable about the origin explained by the regression, which cannot be compared to the R² for models which include the intercept.

Table 11 shows that, within a framework that accounts for many of the shortcomings of previous analyses on the farm size-efficiency relationship, farm profit (net of family labor) per unit of capital invested is negatively related to operated farms size (OP) (although it is not statistically significant in Vaalharts), but positively related to the percentage of the operated area owned (OW). This further complements the findings obtained from the TFP and non-parametric analyses: farm size tends to be inversely related to efficiency, however, larger owned areas are positively related to higher farm profits per unit of capital. In addition, the supervision component (H) is also positively related to farm profitability (although it is not statistically significant for the Ruens).

Inclusion of the managerial ability variable (M) yielded interesting results. As a whole, a better fit was obtained. Managerial ability is significantly positively related to efficiency. On the other hand, the z variable yielded mixed results. As expected, it has a highly significant positive relationship with efficiency for the Ruens, but is insignificant for Vaalharts.

In general, the results presented in table 11 are strictly according to prior expectations regarding the signs of the different coefficients. Some specific coefficients, in particular operated area (OW), however, are not significant.

Explaining The Results: Policy, Technology And Management

The different analyses of the farm size-efficiency relationship in the grain producing areas (which represent approximately 60% of all cultivate areas) and the irrigated areas (for crops only) in South Africa yield consistent and complementary results from which it can be concluded that²⁶:

- Farms in the former homelands seem to be scale inefficient. This is not surprising given the history of lack of access to support services and infrastructure, policies discriminating against them and the extremely fragmented and small land use rights of farmers. In addition, credit, information, insurance and labor markets are missing or imperfect.
- There is an inverse relationship between farm size and efficiency in the commercial farming areas for the range of farms analyzed, regardless of the methodology used.
- This inverse relationship in commercial farming seems to become stronger and more accentuated as policy distortions, which largely favor large farms relative to smaller farms, are removed.
- Large farms use relatively more capital intensive methods of production, while smaller farms are more labor intensive.
- Managerial ability seems to be closely related to farm size, with better managers having larger farms.

From these results it is clear that the policy framework is crucial as it has an important impact on the farm size-efficiency relationship. However, even in South Africa where a small group of large commercial farmers have captured most of the benefits from the extremely distorted policy regime which heavily supported them, these were not enough to off-set the disadvantages brought about by higher labor supervision costs and transaction costs associated with labor, and imperfect labor markets. In addition, for the range of commercial farms analyzed, advantages large farms have in access to inputs, credit, services, marketing and distribution opportunities were also negated. The conclusion is that even a policy environment favoring large farms over small ones, resulting in huge social opportunity costs, was not enough to make large farms more efficient than relative smaller farms.

²⁶ High value crops, such as export fruit, were not included in the analyses and as result all of the conclusions would not necessarily also apply to these crops.

In addition, it seems that larger farms have better managers than smaller farms. However, even this 'advantage' was off-set by the supervision and transaction costs associated with hiring a large number of laborers in the more extensive and lower potential rain-fed areas, although it seems to have a bigger impact in the higher potential irrigation areas where some economies of scale were observed at small farm sizes.

These results apply to the existing technologies used on South African farms. These technologies essentially originated in the United States, where labor is relatively expensive and capital abundant, and were adapted to the local situation (Van Zyl and Groenewald, 1987; Van Zyl, *et. al*, 1987). In addition, research and extension concentrated on encouraged the adoption of such technologies, many of which are inappropriate given South Africa's factor endowment. The argument is that small farms, even smaller than the range of farm sizes evaluated in the analyses presented in this paper, will be even more efficient than larger farms if there were more appropriate technologies available, these technologies were properly supported by research and extension, and the policy environment in general was more friendly towards small farmers.

Finally, the results provide some insights on how to think about the farm size-efficiency relationship in general. It supports the idea that economies of scale arise because of missing or imperfect markets, or distortions and pecuniary economies favoring large farms over small farms. It shows, however, that the costs associated with labor supervision, and other labor-related transaction costs, are huge, and outweigh many of the advantages of being large. Even in the South African commercial farm sector, where relatively larger farms have benefited substantially more from a comprehensive range of policies and privileges, it was not enough to compensate for these costs, and an inverse farm size-efficiency relationship is observed. However, markets do exist in these areas and they function fairly well for even the smaller commercial farmers. On the other hand, where they are missing or imperfect, for example in the homelands where the situation is further compounded by a lack of support systems and infrastructure, small farms are less efficient than the larger farms (although all farms are relative small due to over-population and often extreme fragmentation of use-rights).

The farm size-efficiency relationship thus seems to be determined by the relative importance of the factors benefiting smaller farms and those benefiting larger farms. On the balance, how these factors impact on the relationship, and the net outcome of their effects, are influenced by several factors, both individually and together. These include the production relations and technology utilized on the farms, relative factor endowment facing the broader society and managerial ability of the farm manager. For example, managerial ability seems to have a smaller impact where there are other factors which are more restrictive, or where there are no alternative technologies available.. This is the case in the dryland

areas as opposed to where irrigation is available. In the latter situation the upper efficiency boundary of the individual's farm is more reliant on managerial ability than on some exogenous factor such as rainfall. In addition, in an economy where the factor endowment (and relative prices) favor the use of labor, farm size should be smaller because the disadvantages of using labor kick in at smaller farm sizes. Thus, production relations and factor endowment (which includes management) together determine the impact of pecuniary economies and distortions on farm size-efficiency the one hand, and supervision and transaction costs associated with labor on the other.

Implications For Land Reform

The inverse farm size-efficiency relationship, which is also present in South African agriculture despite a history of policies favoring relatively large mechanized farms, implies that significant efficiency gains can be made if farm sizes in the commercial sector become smaller. An important element in such a process would be the removal of all policies and distortions favoring larger farms relative to smaller farms. The basic principle should be to make markets work by removing distortions and privileges favoring large farmers, and creating markets to service small farmers in areas where they are missing without entrenching new privileges. Imperfect markets should be made to work better.

Although the efficiency argument cannot be a judge of the present distribution of land rights given the history of how these rights were acquired, it does provide a powerful argument for land reform in light of the inverse farm size-efficiency relationship observed in South African commercial agriculture. However, a precondition is the removal of all privileges to the farm sector as they tend to favor large farms over smaller ones, as well as the addressing of missing and imperfect markets for small farmers. Thus, the playing field should be leveled.

The results on management and farm size also have important implications for land reform. It further supports the call for flexibility in policies regarding farm size and structure of agriculture, while also showing the value of proper training and extension aimed at increasing the farmer's managerial ability. The results clearly support the notion of a farm structure with smaller farms opening the way for land reform.

The results obtained particularly support the abolishment of the Act on the Sub-division of Agricultural Land (Act 70 of 1970), and in particular the way in which it is applied. Apart from prohibiting the creation of more efficient small farmers in South Africa's commercial areas, applications for the sub-division of agricultural land are based on the notion of 'average management' which is clearly inappropriate.

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